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THE PHILOSOPHY OF PHYSICS[1]

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In appearing here to speak on the philosophy of physics I am in a rather dangerous position. Those of you who are philosophers will want to know by what right I speak on such a subject without having mastered the classical philosophies and without knowing the various traditional answers which have been given to the problems I shall discuss. On the other hand, physicists will accuse me of having left the austere and narrow path of physics to wander aimlessly, or at least uselessly, among the byways of philosophical verbiage. For most physicists have a traditional mistrust of philosophy. A definition of philosophy which usually provokes much self-satisfied mirth among physicists is as follows: Philosophy is the systematic misuse of a terminology especially invented for the purpose.

Yet in spite of this state of mind, the rapid changes in the concepts with which physics deals have almost forced some consideration by physicists of problems which were formerly regarded as belonging to the exclusive domain of philosophers. This consideration has been in the light of experimental results and because of this fact may be of value to the philosophers themselves. As a variation on the proverb that "Truth is stranger than fiction," may I suggest that experiment reveals stranger things than man's imagination has ever invented. Possibly some of the new results of experimental physics may reveal new aspects of old philosophical problems. Hence I propose to describe not so much any one unified philosophy of physics as a series of results of physics which I believe may have some bearing on philosophical problems.

One of the problems which has occupied the minds of philosophers is concerned with the nature of existence. Does there exist a material world, and can any-

[1] An address delivered in a series on "Outlooks in Philosophy" at the California Institute of Technology.

thing be learned about it? On the whole physicists have taken a very naive view of such matters. To my mind it has been this fact, this naiveté of view-point, which has contributed much to the successful development of physics.

When physics entered the experimental phase about the time of Galileo, troublesome questions of existence were ignored, and it was assumed, often without adequate consideration, to be sure, that there existed an outside material world which could be contacted through the senses. It was also assumed that these sense contacts could be reliably interpreted and that an observer could actually learn the nature of this outside world through his observations. To the scholars of Galileo's day this was not at all a self-evident proposition. It seems self-evident to some of us to-day because we have been brought up that way, but three hundred years ago people were apparently much more impressed with the possibility that things are not what they seem than with the simpler problem of at least seeing what they seem to be.

As is often the case with apparently simple statements, the simplicity becomes less obvious when the matter is considered more carefully. If one considers the statement that there exists an outside material world, the question arises, "what is it outside of?" Is it everything outside of the person who is speaking or is it outside of something else also? An active physicist rarely stopped or stops now to consider such a question. He is so busy observing things in this outside world that he has no time to bother about its strict delimitation, although he probably realizes instinctively that there must be a division somewhere between himself and this world which he is to observe. He is usually willing to admit that his hands and his feet belong to the outside world. He can apply to their movements the laws of mechanics, and he is willing to suppose that the physiological processes which go on in them can be objectively described. When he has a sore throat or a headache he is willing to consider himself as an onlooker observing these things. On the other hand, he certainly thinks of himself as something apart from these physiological phenomena, something in the nature of an observer who can watch the outside world go by. The naive view must also recognize the fact that there are other observers, and it assumes that they all see essentially the same things, and in fact can tell each other about them.

Thus I think that, largely without a formal organization of their thoughts, most physicists regard the world as made up of two kinds of things: (*a*) Physicists and, if pressed, other persons or potential physicists will be included in this select group, and (*b*) the outside material world which can be studied and discovered. It is true, of course, that there are variations on this division. There are those who in the attempt to be consistent will include all other persons in the group of things called the outside world, and others pushing still more firmly toward the apparently logical necessity will want to include themselves also in this outside world. I doubt, however, if these two latter groups are really motivated by the philosophy which they defend. I have heard psychologists complain of lack of sympathy from physicists in the attempt to apply the methods of physics to psychology, and I suspect that this lack of sympathy was due to the probably subconscious feeling that the psychologists were not properly recognizing this division of the world into two kinds of things and were getting themselves mixed up with the part of the world they wished to study.

Because of the simplicity of the physicist's attitude, the difficulties in his dualism were not at first troublesome. For instance, the question as to how a sensation got from the obviously material body of the observer to the obviously non-material observer himself was not a troublesome question: every one could see that the sensation did get across the boundary line, and so what more was there to be said about it? Nevertheless, a little consideration of this problem makes it very formidable. Although it may seem quite clear that there are two kinds of things, observers and the material world which is observed, a little consideration shows that not only the nature of the boundary between the two but even the location of this boundary is obscure. As far as the results of physical science are concerned it seems possible to put this boundary at almost any desired point. The observer can with apparent consistency include any desired amount of this outside world in what he may wish to call merely extensions of his senses. The part remaining beyond appears to follow the laws of physics in a perfectly satisfactory manner, and there exists in the laws of physics no reason for assuming the boundary to be one place rather than another.

Consider, for example, that I wish to observe this desk. I am on one end and the desk is on the other end of a chain of interactions. Where shall I draw the line between myself and the thing observed? In the first place, I can draw the line at the surface of the desk and say that the scattering of light from the surface constitutes the act of observing the desk. I can say that the source of light, the light itself, and all the mechanism necessary for the perception of the light is part of me, is an extension of my sense organs. On the other hand, I could also say that what I really observe is the light which strikes the retina of my eye, that this is the point at which the observation really takes place, and that here must be drawn the line dividing the observed things from myself. But I can go still farther and say that the action of the light

on the retina is a purely physical process which can be described by known laws and that the dividing line must be placed at a point at which the nerve impulse reaches the brain. The fact that none of these places seems satisfactory might suggest that there should be no dividing line at all, except for the uncomplicated feeling that there must be made some such division. On the other hand, no one of these interactions shows any characteristics which distinguish it from the others as long as only the classical physics is used, but one of the contributions which has come from the interpretation of the modern quantum mechanics is the recognition of the fact that, although the interaction which may be selected as the dividing line between observer and object is entirely arbitrary and may be put at any desired point, it is nevertheless necessary to put such a dividing line at some point and to treat the interaction at this point in a unique fashion. To make clear the nature of this difference may I outline briefly the method used in the quantum mechanical description of the behavior of an isolated part of the world.

According to the present theory, the state of a mechanical system is described or represented by a mathematical symbol which I shall call the wave function. This symbol carries all the information which can be known about the system in the particular state in which it is. This symbol changes with the time in accordance with a differential equation, known as the Schroedinger equation, in a perfectly definite way. If the state of the system is known at one time it can be predicted for any future time by means of this equation. In case the system is composed of two or more parts, the interactions and mutual influences of these parts are entirely described by this equation. But now suppose I want to examine the system. Suppose I want to see if everything is going on according to the rules, and for this purpose I want to make a measurement of some quantity which pertains to the system. As soon as I touch the system with a measuring instrument, as soon as I make any kind of contact with it sufficiently vigorous to learn anything about it, the symbolic wave function explodes in my face. The interaction between the system and myself in the form of a measuring instrument can not be made gentle enough to leave the system undisturbed and at the same time strong enough to give me some information; and this interaction can not be described by the same Schroedinger equation which described the behavior of the system as long as I did not touch it. The interaction with the observing instrument is subject only to the restriction of Heisenberg's principle of indetermination, which merely states that if the interaction is strong enough to do any good in the way of really making a measurement, it is so strong that the symbolic wave function which previously described the state of the system is no longer of any use.

On the other hand, if an observation of the right kind is made, it results in a knowledge of the state of the system after the measurement and the possibility of assigning to it the proper symbolic wave function. This state will then develop again in the manner prescribed by the equation of motion until another observer interferes with the orderly process. Thus there is a distinct difference in the treatment accorded interactions which take place within an isolated system itself and those which take place with the observer or the observer's extended senses in the form of measuring instruments, and it is just possible that this difference in treatment may be of significance beyond the regions in which it has thus far been applied.

One of the subjects often discussed in connection with the implications of physics is the problem of causality. One hears frequent statements about the principle of causality, the law of causality and more recently about the disappearance of causality from the world of science. The principal difficulty with this subject seems to be to find out what one is really talking about. It seems to be possible to make up a statement of causality which is true, *i.e.*, is in accordance with the observations, but which does not seem to be of much importance. It is also probably possible to make up a statement which seems to be of importance, but which is probably not true. But it is easiest of all to make a statement which sounds well but has no precise content whatever. Most of the few statements of causality which I have read belong to the latter class.

Apparently one of the essential elements of causality is that events shall have some connection in time, that the occurrence of a certain event now is necessarily followed by a certain other event at some later time. I do not mean that this is all that causality implies, but this seems to be at least one thing. However, it seems to me that the existence of some kind of a relationship of this nature is essential to the existence of a science, for the essential element of a science is that the known facts shall be classified. No body of facts, no matter how large or how well authenticated, can properly be called a science until these facts are brought under a suitable system. This system must certainly involve relations in time as well as in other ways, and so a kind of causality must be imposed if it is not already obvious, in order that there can be a science. Many of those subjects of study which aspire to be called sciences but which are not yet properly such, lack just this essential element. When a historian can read the papers to-day and tell what will happen to-morrow, then history will be a science, and no one will question the application of the term.

As I have already indicated, this causality, this uniform development in time, has been assigned in quantum mechanics to the symbolic wave function which describes the state of that part of the outside world under consideration. This symbolic wave function and its law of change carry within themselves the usual conservation laws, such as the conservation of energy, the conservation of momentum and the conservation of angular momentum. On these conservation laws rests the usual idea of determinism. The symbolic wave function does not carry, however, a detailed space-time description of the motions of the particles of which the mechanical system is composed. This wave function is quite an abstract thing. It can not be observed directly, and its connection with observations to be made on the system is, in general, only statistical. Thus it is true that the present mechanics does not permit an exact prediction of the result of a measurement to be performed to-morrow. It permits only statistical or probability predictions to be made in most cases.

Does this mean that there is no causality in physics? This still depends entirely upon what you mean by causality, upon what you want causality to do for you. To many persons the term causality is associated with the ideas of determinism and free-will, and the significance to be attached to the problem is because of its connection with ideas of moral responsibility.

At the time of the rapid development of Newtonian mechanics and its phenomenal success in describing and predicting the motions of the members of the solar system, there grew up the belief that all problems were to be solved by such essentially mechanical means. In particular it was concluded that our conscious mental processes were to be determined and described in terms of motions of atoms in our brains. Although this conclusion is clearly at variance with the simple dualism in terms of which physicists normally think, there were many persons who believed it to be a direct consequence of the thinking of physicists. The discovery of the statistical element in the predictions of quantum mechanics was seized upon by some as a means of escape from these unpleasant conclusions. It was suggested that although natural laws operate in all phenomena, they are not to be regarded as determinative, but merely as restrictive. Inside the range permitted by the statistical laws, free-will might be supposed to act.

In spite of this suggestion, I think it is now agreed by most physicists who have considered the matter that the conclusions from Newtonian mechanics to a materialistic determinism in phenomena of consciousness as well as the conclusion from quantum mechanics to a possible freedom of will are entirely without any justification in physics. In reaching such conclusions the naiveté of the physicist has over-reached itself and has produced a very superficial answer to a poorly understood problem.

Nevertheless, there has grown up under the influence of Bohr a recognition that certain aspects of the methods of quantum mechanics may provide a point of view useful in problems of this kind. As I have already indicated, the machinery of quantum mechanics provides for certain conservation laws, but does not at the same time provide a detailed space-time description of events. There are in the problems of atomic physics two complementary but mutually exclusive aspects, both of which are necessary to a complete description of the phenomena, but neither of which is adequate by itself. For instance, an electron is found to behave under certain circumstances as a wave, and under other circumstances to appear to have a clearly localized position as if it were a small particle. The achievement of the theory is in renouncing any attempt to describe one of these aspects in terms of the other or to establish any detailed connection between them, and in the recognition of this complementarity as fundamental. Certainly waves and particles are not the same thing; in fact, they are mutually exclusive things, and the recognition that in spite of this an electron has properties of both kinds is a real change in modes of thinking. In some such way one might imagine that problems of consciousness may have two complementary aspects. One of these aspects might suitably be described by such words as freedom of choice, while the other might be described in terms of physical or chemical reactions. The progress in understanding would come with the recognition that one of these descriptions does not exclude the other, but that they represent entirely different aspects of the problem. This rather surprising point of view which has been forced upon us by the results of actual experience may be one of the major contributions which physics has to make to philosophy.

May I now turn to another point. During the past fifty years much of the attention of physicists has been devoted to the structure of matter. Some twenty-five hundred years ago the philosophy of atomism was quite in favor, and it is now in favor again. The idea that all matter is made up of a few kinds of atoms was apparently recommended to the ancients as a method of getting some order into an apparently chaotic universe. Certainly until recently there was no more immediate reason for such a belief.

The essential idea of atomism is that the properties of matter can be explained in terms of relationships between elementary atoms. If this is to be done satisfactorily the atoms themselves must have very few and very simple properties, and it must be their combinations in various ways which produce the wide variety of phenomena which are observed. When the

atoms of the chemical elements were discovered well over a century ago they were moderately satisfactory in this respect. There were only a few varieties of them and their principal properties were a definite weight and a definite combining power. However, this simplicity did not last long. It became necessary to ascribe to the atoms themselves all sorts of special properties, and the study of atomic physics has led to the conception of a chemical atom as a very complex dynamic system. Nevertheless, the search for and the belief in ultimate indivisible atoms has gone on. At the present time there is again a small number of relatively simple atoms which one might call fundamental or ultimate. These are the positive and negative electrons, the proton, the neutron and possibly the neutrino. These are relatively simple. They each have a characteristic mass, a characteristic electric charge, and they each act on other particles with characteristic forces. In addition each of them appears to have a spin and a magnetic moment. Out of these basic atoms can be built, it is believed, all the varied and complex material world with which we are acquainted.

In so far as this can be done the picture is satisfactory. It looks as though the goal of the ancient atomists has been closely approached and statements have been heard to the effect that physics is finished, that there is nothing more left to do.

Usually when one is discussing indivisible atoms there comes along a cheerful soul who wants to know the structure of these ultimate atoms. He wants to know how big an electron is and what a proton is made of. The very asking of such a question is a denial of the fundamental nature of the particle in question. If a proton is really a fundamental atom there can not be anything smaller of which it can be made; there can not be any units in terms of which its size can be measured. As soon as it becomes necessary or desirable to talk about the structure of these ultimate particles their usefulness as ultimate particles is gone. It remains yet to be seen, of course, and will always remain to be seen experimentally, whether we shall have to have sub-electrons or sub-protons to explain how the electrons and protons work. Considerable effort has already been expended on the problem of the existence of an electrical charge smaller than that of an electron, but no such has been found. One can say that with the present experimental techniques an electron must always be taken whole.

However, the thing which I believe is of some general interest is that theoretical physics has developed methods for handling this kind of a situation. There have been adopted mathematical symbols and rules for interpreting them which describe the behavior of electrons and the other basic atoms in use. Within the framework of these rules there is at present no place for questions as to the structure of the particles involved. To the question how many electrons are there in this certain region the answer will always be one or two or three or some other integer. The theory is so built that the answer 1.5 can never be given. This is to my mind a real advance in the method of dealing with atoms. Whether it remains satisfactory can only be determined in the future, but the fact that it seems useful in a wide variety of fields suggests that possibly a limit is being approached in the process of subdividing matter, and that further subdivision may be unnecessary.

Thus far I have been discussing the results of physics which may have some bearing on philosophical problems. This should not be taken to imply that philosophers have ignored the results of physics. Such an implication would be far from the truth. As I have already stated, the remarkable successes of the mechanics of Newton were so impressive that various mechanistic philosophies were based on them. In this development the experimental physicists apparently played a secondary rôle. They seemed content to make their discoveries in the slow and laborious manner in which such discoveries must be made and to leave the generalizations to others. But the philosophers whose business it was to take a large scale view of things eagerly seized upon the laws of Newtonian mechanics as the long-sought-for ultimate and eternal truth. Upon the assumption that it would be possible in the future to discover suitable mechanical laws governing all phenomena, and with this assumption bolstered up by the successes of Newtonian mechanics, the advocates of materialistic and mechanistic philosophies wrote weighty tomes expounding their views. There developed at the same time, however, exponents of idealism or subjectivism who eagerly joined battle. I think that the apparently endless debates between opposing schools of philosophers have had much to do with the development of that distrust which most experimental scientists seem to feel for philosophy.

Curiously enough, this distrust of philosophy led in the latter part of the nineteenth century to another philosophy. It has been called a philosophy to end all philosophies, and it is designated by its proponents as the only true scientific view of the world. Although it has numerous opponents, it is more or less the official philosophy of physics to-day.

This philosophy designates as meaningless many of the questions ordinarily considered by philosophers. Only those problems are credited with significance which can be answered in terms of experiments or observations. This point of view has been called positivism.

The central feature of positivism is its insistence

upon empirical or experimental data as the only object of scientific study and its emphasis upon the descriptive feature of scientific theories. According to a positivist the object of a scientific theory is to classify and describe quantitatively and precisely the sensations which we experience. The use of the term "explain" in this connection is undesirable, because it carries with it connotations of some real world in terms of which the explanation is to be made and in terms of which things can be understood.

An extreme positivist tends to be a subjectivist. He denies the existence of a material world and will admit the reality only of sensations which it is his task to classify and describe. A more reasonable positivist says that the question as to the existence of an outside world has no meaning. It is impossible to give any satisfactory definition of the term existence except as a symbol by means of which experiences can be classified. A working physicist says, "I don't care whether there is an external world or not. It appears as though there were one and I can get results by assuming its existence."

The position of a positivist is a very strong one. He formulates the rules of the game so that any question which he can not answer can be declared to be meaningless. His point of view permits him to formulate satisfactorily such apparently irrational concepts as those of the theory of relativity and the quantum theory without talking so much about revolutions in physics as do the exponents of other philosophical systems. For these revolutions have not really been in physics but in the philosophies based on the physics. They have not disturbed the physicists so much as the philosophers. It is sometimes said that Einstein has superseded Newton and that the theory of relativity has eliminated Newtonian mechanics. If this were true our students might well demand their money back, for our hard-boiled faculty insists that they grind their noses on Newtonian mechanics for many long years. Furthermore, very few designers of machinery find it necessary to use Einstein's mechanics in writing their specifications. To a positivist this is all as it should be. The Newtonian mechanics was a means of classifying a certain set, and a very large set, of experiences. But when the Michelson-Morley experiment was performed, when the unexpected precession of the orbit of Mercury was established, when the bending of light around the sun was observed, it became necessary to adopt some wider, some more general scheme of classification which would include these additional facts as well. This was of course a revolution to those who had extrapolated Newtonian mechanics to cover all phenomena, but it was no revolution to a physicist and it would not perturb a positivist.

It is possible to illustrate the difficulties which a philosophy based on the existence of a real material world may have with the theory of relativity. According to this theory, which, it must be remembered, is merely an abstract statement of observed experimental facts, the length of an object depends upon its motion relative to the physicist who measures it. When measured by different observers moving relative to it with different velocities it appears to have different lengths. What, then, is the true length of the object? The theory of relativity and the positivist philosopher say it has no true length. One measurement is as good as another for determining the length, and the business of the theory is to state the connection between the different observations. The exponent of a real material world which is being discovered by means of the measurement will find himself in a difficult position. He can, it is true, say that length is not a fundamental attribute of objects in the real world but is a secondary quality such as color. When he does this, however, the suspicion keeps creeping in that it may be impossible to discover any attributes of the real world which are satisfactory in this sense.

In quantum mechanics the situation is even worse. The experiments on light have shown that at times light behaves as though it were a train of waves, while at other times it acts as a stream of corpuscles. The positivist is not displeased with this. He merely proceeds to build up a system of classification and description which will include all the observations, and after having built up such a system he is happy. His only further objective is to build a system of description which will include as many phenomena as possible, ultimately to include all phenomena. He would then have a complete philosophy. A philosopher of another persuasion, however, will want to know something of the nature of the reality behind this apparent paradox, and this desire will put him in a bad predicament, for waves and corpuscles are essentially different things. They have in fact mutually exclusive properties and as far as I know no one has yet been able to formulate an adequate picture of a reality to be behind these sensations.

As I have said, positivism is logically a very strong position. As far as I know, it is the only position completely tenable in the face of the experimental facts of relativity and quantum mechanics. Yet it is not without difficulties and has its strong opponents. In the first place, there is the usual difficulty with the position that all truth is sensation or experience. For different persons have different experiences and no two see alike. In order, then, to avoid a complete solipsism in which each philosopher is his own universe it is necessary to select in some way the experience which is more or less common to a number of observers. As soon, however, as this is done the whole

question of the real difference between those sensations on which different persons can agree and those on which they differ comes up and the problem is open again. So positivism seems to face the dangers of all subjective philosophies.

Positivism has also been attacked as a philosophy of resignation and defeat, as a refusal to admit the existence of problems for which no solution can immediately be seen. Fifty years ago the positivists denied the reality of atoms. Atoms, they said, are convenient means by which to describe the results of observation, but they are by their very nature such that it will be impossible ever to isolate and observe one. It has no sense to speak of their existence. Experience since then has not justified this position. Those who have made advances in physics have been those who took the atoms seriously, who went out and found methods by which individual atoms could really be observed, and if to-day a positivist still maintains that atoms and electrons are only useful fictions, he must admit that they are at least as useful and necessary as anything else whose reality he would affirm.

Thus while positivism is a philosophy which a physicist can easily defend, I am inclined to believe that it is not the philosophy which really motivates him. I am inclined to believe that those most effectively active in physics to-day have the very naive view which I mentioned at the beginning. They tend to believe that there is a real world which can be discovered, and they propose to discover it.

THE URSI PROGRAMS OF SHORT-WAVE STATION W1XAL

By Dr. A. E. KENNELLY

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THE Union Radio-Scientifique Internationale (abbreviation URSI), as its name indicates, is an International Union, founded in 1919 under the auspices of the International Research Council, for world study of radio science. It has sections in some twelve countries of the world and its Secretariat is at 54, Avenue des Arts, Brussels, Belgium. The Secretariat of the American Section is at the National Bureau of Standards, Washington, D. C. It has two official languages, French and English, for its reports, papers and discussions.

The URSI seeks to build up and to spread international knowledge of the scientific principles of radio communication and has held plenary meetings at two- or three-year intervals, the first in 1922, at Brussels, and later in Washington, D. C., London, Brussels and Copenhagen.

It was soon recognized that radio communication is affected by certain changes in cosmic phenomena such as (1) spots on the surface of the sun, (2) electric and magnetic disturbances on the earth, as well as in the upper regions of our atmosphere. In order to bring such cosmic changes promptly to the notice of radio observers in various parts of the world, the French Government in 1928, at the suggestion of the late General Ferrié, the founder and first president of the URSI, inaugurated a daily service of radio-cosmic bulletins, broadcast from the Eiffel Tower Station in Paris, which bulletins came to be known as Ursigrams. These Ursigrams, emitted in international dot-dash signals, were expressed in cipher code groups containing data of solar and terrestrial surface changes affecting radio. These messages, picked up in various countries by radio observers, and recorded by them in cipher code, were decoded into the languages of the various countries. Since 1929 these Eiffel Tower Ursigrams have been repeated daily in broadcasts from the long-wave radio station at Lafayette near Bordeaux and the shortwave station at Pontoise near Paris.

In 1929 the American Section of the URSI, recognizing the value of the Ursigram service in radio communication, enlisted the cooperation of a number of scientific institutions in America for the establishing of an American daily Ursigram service. These institutions have been the U. S. Coast and Geodetic Survey, the National Bureau of Standards at Washington, Smithsonian Institution, Carnegie Institution, Mount Wilson Observatory, assisted by the United States Government departments of Army, Navy and Weather Bureau.

Through the aid of Science Service at Washington, D. C., these institutions were enabled to collaborate for the emission of a daily Ursigram in international dot-dash signals from the U. S. Navy Station NAA at Arlington, Va., near Washington, D. C. Changes in the solar surface were reported from Mount Wilson Observatory; changes in the solar radiation intensity at the earth's surface were reported by the Smithsonian Institution; terrestrial magnetic observations by the Coast and Geodetic Survey; observations of aurora borealis in Alaska were supplied by the Car-

negie Institution; measurements of reflecting-layer heights and critical frequencies in the ionosphere by the National Bureau of Standards.

Since August 1, 1930, these observations have been forwarded daily to Science Service, Washington, by the aid of U. S. Army radio network. Science Service makes up a daily Ursigram in cipher code from the data received and forwards this to the U. S. Navy Department for the evening broadcast by U. S. Navy Station NAA. Additional cosmic data for the Ursigrams has been supplied by the Japanese Section of the URSI as well as from observers in the Philippine Islands.

The American Ursigram from NAA, broadcast every day of the year, has been of distinct service to radio operators in various countries by furnishing them advance information as to cosmic disturbances likely to interfere with radio communication. Until this year, however, all these Ursigrams have been carried by dot-dash signals of international Morse code. They can, therefore, only be received by persons trained as radio operators. The number of such radio-trained operators in the various countries of the world is naturally limited.

On February 1, 1937, short-wave station W1XAL at Boston, Mass., in liaison with Science Service at Washington, opened a daily URSI program by radio telephone in plain English, thereby supplementing to a much larger available audience of world listeners the coded Ursigrams.

W1XAL is a broadcasting station employing shortwaves only. Its charter does not permit of broadcasting advertising or commercial information; its purpose being to disseminate cultural and educational information. It is supported by voluntary contributions, at present aided by a Rockefeller Foundation grant. The station operates with a power not exceeding 20 kilowatts on any one of four frequencies (6.04–11.79–15.25– and 21.46 Mc p.s., corresponding severally to wave-lengths 49.6 m 25.4 m–19.6 m and 13.9 m). The radio telephone broadcasts from this station have been reported as successfully received in practically all parts of the civilized world. The purpose of W1XAL is not only to disseminate cultural and educational information, but also to build and spread international understanding, cooperation, sympathy and good-will.

W1XAL seeks to interest a much larger number of scientific students around the world in telephonic Ursigram information than can be reached in the regular channels of dot-dash broadcasts through NAA. This change of vehicle from dot-dash signals to the spoken word introduces a new venture in scientific broadcasting. To English-speaking listeners everywhere the new W1XAL Ursigram broadcast should be as readily understood as any telephonic news broadcast, but to listeners in the various non-English-speaking countries it is desirable that the English language used be modified so as to be more readily understood; long and complicated words should, of course, be eliminated and the vocabulary employed should be as short and simple as may be practicable.

The Orthological Institute at 10, King's Parade, Cambridge, England, has promulgated for a number of years a simplified form of the English language, called "Basic English," suitable for verbal and written communications among elementary students of English in non-English-speaking countries. Basic English contains less than 1,000 selected English key-words, so that a non-English-speaking listener by learning the meanings of these words is able to understand communications in English which would otherwise be beyond his reach.

Basic English is now being officially taught in various European and Oriental countries as a secondary or international language, and more than fifty books have already been printed in Basic English for carrying this work into effect. It is generally admitted that Basic English not only furnishes a direct avenue for subsequent study of standard literary English, if desired, but also enables scientific information to be conveyed to a listener or reader with the minimum amount of linguistic effort on the part of both speakers and listeners. It frequently happens that an English-speaking reader opening for the first time a book printed in Basic English does not notice anything unusual about the text except what might be attributed to the literary style of the author. It would seem, therefore, that a good opportunity exists for increasing the number of world students interested in cosmic science and radio by the use of simplified English broadcasting at W1XAL.

The daily Ursigram Service of W1XAL has already been found suitable for swiftly conveying cosmic information, such as earthquakes and astronomical events of international significance, to all parts of the world. A few hours after W1XAL started its daily Ursigram service (21:55–22:00 world time, or GCT) an unexpected comet was recorded at Harvard College Observatory, Cambridge, U. S. A., on certain photographic plates of the northern sky. Dr. F. L. Whipple, of the Harvard Observatory, repeating and comparing similar plates on February 7, verified thereby the presence of a new small comet of the twelfth magnitude, in the Hunting Dogs constellation (Canes Venatici). Within a couple of hours of its official discovery at Cambridge Observatory the comet was reported in the daily Ursigram of W1XAL for worldwide distribution. This new comet on February 15 was at 35° 26′ North Declination and 13h 19m 30s

Right Ascension. This comet then had a tail of about one degree in length and it was traveling east and north about one third of a degree daily. It is estimated that this new comet (the first to be announced by URSI radio) will be closest to the sun and earth on June 22, 1937, at which date it is believed it will have attained the eighth or seventh magnitude, still too faint for the unaided eye but visible through a small telescope. Through the URSI announcement this new comet will probably have been under observation in many parts of the world and its discovery just after W1XAL opened the Ursigram broadcasts is a good augury.

The W1XAL URSI-broadcasts are emitted every day on a frequency of 11.79 Mc/sec. (wave-length 25.4 m) at 21:55–22:00 GCT, or 16:55–17:00 Eastern Standard Time (EST). The weekly URSI summary of cosmic events is being added every Monday, immediately after the daily URSI broadcast—*i.e.*, at 22:00 GCT so that, although the regular daily broadcast lasts only five minutes, the weekly broadcast on Monday may last twenty minutes or more.

SCIENTIFIC EVENTS

PRINCIPAL ADDRESSES AT THE DENVER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

On Wednesday evening, June 23, the Maiben lecture of the American Association for the Advancement of Science will be delivered in Denver, Colorado, by Professor Nevil V. Sidgwick, F.R.S., of Lincoln College, Oxford, England. The association is particularly fortunate in securing this distinguished British scientist for one of its principal addresses. Dr. Sidgwick is not only eminent as a chemist but has rare personal qualities and an extensive acquaintance with America and American science. An American chemist, referring to Dr. Sidgwick, recently wrote:

> He has frequently been in the United States, in fact, has been fond of spending his holidays in the Rocky Mountains. He attended the Pittsburgh meeting of the American Chemical Society last September and I believe the Tercentenary at Harvard University as well.
>
> He is a kindly, lively and lovable gentleman who has made many friends among the chemists of the United States. . . . He has reached the apex of his achievements during the past ten years. . . .
>
> Dr. Sidgwick was the non-resident lecturer in chemistry at Cornell University in 1931 and in May of that year delivered the Edgar Fahs Smith birthday address in the Harrison Laboratory of the University of Pennsylvania, his subject at that time being "Atomic Cohesion," . . . .

It is interesting that Dr. Sidgwick "has been fond of spending his holidays in the Rocky Mountains," for the plans for the Denver meeting provide for a very attractive series of excursions into the magnificent Colorado mountains, the lower slopes of which in June are covered with flowers and the tops of which are white with snow.

On Tuesday evening, June 22, Dr. Herbert M. Evans, professor of biology and director of the Institute of Experimental Biology of the University of California, will deliver his address as retiring president of the Pacific Division of the association. The title of his address is, "The Development of Our Knowledge of Anterior Pituitary Function."

Dr. Evans was educated at the University of California, the Johns Hopkins University and Freiburg University, and he has been a member of the faculty of the Johns Hopkins University, as well as of the University of California. He has published many scientific papers and has been honored by membership in many scientific societies, including the National Academy of Sciences.

On Thursday evening, June 24, Dr. A. E. Douglass, professor of astronomy and director of the Steward Observatory of the University of Arizona, will deliver the John Wesley Powell lecture of the Southwestern Division of the association. The subject of his address is "Tree-rings and Chronology."

Dr. Douglass was educated at Trinity College, Connecticut, and at Harvard University. In addition to his contributions to astronomy, he has been a leader in extending chronology, particularly as it pertains to climatic variations, backward over long periods of time by studies of tree-rings. By this method, he has thrown much light on the climatic conditions surrounding prehistoric Indians of the Southwest.

It will be clear from these brief statements respecting the principal evening lectures at the Denver meeting that the association will present an unusually varied and interesting program, ranging from the fundamentals of chemistry to the remarkable functions of the anterior part of the pituitary gland, and to chronology as revealed by tree-rings. Together the lectures touch on an extraordinarily wide range of rapidly developing science.

F. R. Moulton,
Permanent Secretary

THE AMERICAN CHEMICAL SOCIETY

At the North Carolina meeting of the American Chemical Society, President Edward R. Weidlein presented the following statement prepared by Dr. Charles

L. Parsons, secretary and business manager of the society:

The prosperity of the American Chemical Society and its usefulness to its members and to the country continues on an accelerating curve. The membership of the society is now slightly above 20,000, its goal as set for the end of the present year. Two thousand two hundred and eight new members have been added to the society from January 1 to date, making the total membership of the society 20,007. In spite of the increased number, 20 less members have resigned in 1937 to date than in the same period of 1936. Also the unpaid membership is 66 less than it was in the corresponding period of last year. Subscriptions to all the society's journals have notably increased, especially to *Industrial and Engineering Chemistry*. In the first three months of 1936 there had been an increase in subscribers to the industrial edition of *Industrial and Engineering Chemistry* of 942; in the first three months of 1937, there was an increase of 1,624 subscribers. The analytical edition had almost the same increases, but the news edition naturally increased more extensively, as it goes to all $9.00 paid members, whether they voluntarily otherwise subscribe or not. The subscriptions to the news edition as of April 1 was 21,617. There has been a good increase of advertising receipts, and an average increase of about 10 per cent. in the society's normal receipts from membership dues, subscriptions, sales of back numbers and miscellaneous.

The expenses, however, have been increasing out of proportion with the increase in membership, owing to the social security taxes and increased cost of paper and labor. New contracts have had to be signed covering these costs, and it would appear that increased costs of taxes, paper and labor have only begun. Owing to the increased membership, increased facilities of files, typewriters, safe and other equipment have become necessary, but it appears certain that the American Chemical Society again in 1937 will surely balance its budget. This is partly due to the fact that nearly a year's supply of paper was bought in advance, both for the society's normal publications and for the Third Decennial Index, and is in storage in Easton.

It is quite evident that in 1938 the society will have a larger percentage increase in its costs than it has to-day, or will have in 1937, owing to the advanced contracts, of which we have had immediate benefit.

The secretary is pleased to report to the directors that he has received contributions from the industry to the Third Decennial Index to date of $115,840 partly paid in advance. The society is bound by the proposition sent to the industry to offer to return to it any excess over $100,000, and this will shortly be done. A list of contributors, with amounts of those giving $300 or more, will soon be published in the news edition.

SYMPOSIUM ON THEORETICAL PHYSICS AT THE UNIVERSITY OF MICHIGAN

THE Symposium on Theoretical Physics at the University of Michigan, to be held between June 28 and August 20, will be devoted primarily to nuclear physics. To date the following lectures have been arranged:

Professor Enrico Fermi, Royal University of Rome: "Theory of Beta Disintegration"; "Neutrino Theory of Light." June 28 to July 17.

Professor C. E. Uhlenbeck, University of Utrecht: "Recent Problems in Statistical Mechanics with Applications to Nuclear Structure." Throughout the session.

Professor James Franck, the Johns Hopkins University: "The Physical Background of Photochemistry in Solutions with Application to Photosynthesis." During week of July 19.

Professor L. H. Thomas, the Ohio State University: "Numerical Solution of Wave Equations"; "The Normal State of the Nucleus of H^3"; "Collisions of Neutrons with Deutrons." July 23, 30 and August 6.

Professor Kasimir Fajans, University of Michigan: "Chemical Forces and Atomic Structure." Three weeks, beginning on July 26.

Dr. F. N. D. Kurie, University of California: "Beta and Gamma Radiation." June 28 to July 17.

The fifty-inch cyclotron and a million-volt high potential equipment which have been in active operation during the past year will be available for research during the summer. Those interested in this work should write early for particulars. In addition, the department offers numerous graduate courses and also facilities for research in many lines of theoretical and experimental physics. Holders of doctor's degrees may attend all sessions as guests of the university.

THE FINNEY-HOWELL RESEARCH FOUNDATION

A FOUNDATION for the study of cancer is provided for in the will of the late Dr. George Walker, head of the Out-patient Surgical Department of the Johns Hopkins Hospital, who died from cancer on March 31.

The foundation is called the Finney-Howell Research Foundation, in honor of Dr. J. M. T. Finney, emeritus professor of surgery at the Johns Hopkins University, and Dr. William H. Howell, emeritus professor of physiology, both of whom are placed on the board of the foundation under the terms of the will.

The primary object of the foundation is to provide a series of fellowships, each with an annual stipend of $2,000, for the study of cancer. Special grants may be made to support the work being done by the fellows. It will not have a laboratory or institute of its own. The money is to be spent entirely in supporting the work done by the fellows.

The principal must be expended within ten years. The fellowships will be annual appointments, but may be renewed for a period of three years. They are not limited to this country, but can be awarded to workers in institutions in any part of the world. It is stated that the available fund at the disposal of the founda-

tion will amount to $300,000, so that it will be possible to make awards of at least 15 fellowships each year for a period of ten years.

A meeting of the Board of Directors will be called soon to formulate announcements in regard to applications and awards and to make such regulations as may be thought necessary to initiate the work of the foundation.

Members of the board of scientific directors are: Dr. Philip Bard, Dr. Curtis F. Burnam, Dr. John M. T. Finney, Dr. William A. Fisher, Dr. Wade Hampton Frost, Dr. William H. Howell and Dr. Warren Lewis, of Baltimore; Dr. Evarts A. Graham, of St. Louis; Professor E. L. Kenneway, of London; Dr. Jonathan C. Meakins, of Montreal, and Dr. Florence Sabin, of New York. The financial directors of the foundation are: Jesse N. Bowen, Frederick G. Boyce, Jr., and Lee E. Daly, all of Baltimore.

THE AMERICAN PHILOSOPHICAL SOCIETY

At the annual meeting of the American Philosophical Society, held at Philadelphia on April 22, 23 and 24, the following members were elected:

Class I—Mathematical and Physical Sciences: Eric Temple Bell, Pasadena, Calif.; Vannevar Bush, Belmont, Mass.; James Franck, Baltimore; Ernest Orlando Lawrence, Berkeley; Charles Edward Kenneth Mees, Rochester, N. Y.; Otto Struve, Williams Bay, Wis. *Foreign Nominee:* Werner Heisenberg, Leipzig.

Class II—Geological and Biological Sciences: Thomas Barbour, Cambridge; Henry Bryant Bigelow, Cambridge; Herbert Spencer Gasser, New York; Ralph Stayner Lillie, Chicago; William Pepper, Philadelphia; Alfred Marston Tozzer, Cambridge; Hans Zinsser, Boston. *Foreign Nominees:* Sir Frederick Gowland Hopkins, Cambridge; Hans Spemann, Freiburg.

Class III—Social Sciences: Herbert Eugene Bolton, Berkeley; Edmund Ezra Day, New York; Herbert Funk Goodrich, Philadelphia; Nathan W. Hayward, Philadelphia; Samuel Eliot Morison, Boston; George W. Norris, Philadelphia. *Foreign Nominees:* William E. Rappard, Geneva; Charles Rist, Paris; Harold William Vazeille Temperley, Cambridge.

Class IV—Humanities: William Scott Ferguson, Cambridge; Robert Frost, S. Shaftsbury, Vt.; Herbert Putnam, Washington, D. C.; Edward Sapir, New Haven; Preserved Smith, Ithaca, N. Y.; John S. P. Tatlock, Berkeley. *Foreign Nominees:* Charles Marie Joseph Bédier, Paris; Sir Frederic George Kenyon, London.

Officers reelected were: *President,* Roland S. Morris; *Vice-presidents,* Edwin G. Conklin, Robert A. Millikan and Henry H. Donaldson; *Secretaries,* John A. Miller and William E. Lingelbach; *Curator,* Albert P. Brubaker; *Treasurer,* Fidelity-Philadelphia Trust Company; *Executive officer,* Edwin G. Conklin. Luther P. Eisenhart, Alfred N. Richards, John M. Scott and Edward Capps were elected members of the council.

RECENT DEATHS

Dr. LeRoy Wiley McCay, from 1892 to 1928, when he retired with the title emeritus, professor of chemistry at Princeton University, died on April 13. He was seventy-nine years old.

Dr. Robert Heywood Fernald, director of the department of mechanical engineering and dean of the Towne Scientific School at the University of Pennsylvania, died on April 24 at the age of sixty-six years.

Dr. O. P. Hood, who retired last June as chief of the technological branch of the Bureau of Mines, died on April 22. He was seventy-one years old.

Dr. Harry L. Hall, from 1925 to 1929 assistant professor of physiology at the Emory University School of Medicine, died on April 22 at the age of sixty-four years.

Charles T. Ames, for thirty-one years director of the Holly Springs, Miss., Experiment Station, died suddenly on April 18.

The death at the age of seventy-three years is announced of Professor Paul Janet, director of the School of Electricity, Paris, formerly professor of physics in the University of Paris.

SCIENTIFIC NOTES AND NEWS

On the occasion of the celebration of Founders' Day on June 1 at the University of Manchester, the honorary degree of doctor of science will be conferred on Sir Henry Dale, Nobel Laureate, director of the National Institute for Medical Research, Hampstead. As previously announced, Sir Henry will address the Academy of Medicine of Washington, D. C., on May 8 and will give the eighth Harvey lecture of the current series at the New York Academy of Medicine on May 20. He will speak on the chemical transmission of the nerve impulse from nerve to muscle.

Dr. Walter E. Garrey, professor of physiology at the Vanderbilt University School of Medicine, was elected president of the American Physiological Society at the recent meeting at Memphis.

Officers of the American Society for Pharmacology and Experimental Therapeutics have been elected as follows: *President,* Professor A. L. Tatum, the University of Wisconsin; *Vice-president,* Professor E. M. K. Geiling, the University of Chicago; *Secretary,* Dr. G. Philip Grabfield, Harvard Medical School; *Trea-*

surer, Professor Charles M. Gruber, Jefferson Medical College. Professor Paul D. Lamson, of the Vanderbilt University School of Medicine, was elected to succeed Professor E. K. Marshall, Jr., of the Johns Hopkins University, as editor of the journal of the society.

AT the St. Louis meeting of the American College of Physicians Dr. William J. Kerr, professor of medicine in the School of Medicine of the University of California, San Francisco, was named president-elect, to serve in 1938–1939. President-elect Dr. James H. Means, of the Harvard Medical School, was inducted into office as president, succeeding Dr. Ernest B. Bradley, of Lexington, Ky. It was voted to hold the twenty-second annual convention next spring in New York City.

DR. RALPH E. CLELAND, professor of biology at Goucher College, is the first recipient of the John F. Lewis Award of the American Philosophical Society. The award, consisting of a diploma and the interest from a fund of $10,000, established by Mrs. Lewis, will be given annually for the "discovery of a truth in the field of knowledge deemed to be of real significance."

THE John Phillips Memorial Medal of the American College of Physicians was presented to Dr. Richard E. Shope, of the Rockefeller Institute for Medical Research, at the St. Louis meeting. The medal was awarded to Dr. Shope for his research work on the virus which causes human influenza and its close relationship to influenza in swine.

THE National Institute of Immigrant Welfare presented its annual awards to three "foreign-born citizens who have made significant contributions to American life," at a dinner in New York City on April 22. The recipients were Henry Morgenthau, Dr. Aleš Hrdlička and Dr. Leo Hendrik Baekeland. The award to Mr. Morgenthau was for his public service; to Dr. Hrdlička, curator of anthropology of the Smithsonian Institution, for his contributions to anthropology, and to Dr. Baekeland, "inventor of bakelite—a discoverer of resourcefulness and distinction," for his services to science.

THE first Albert Ketcham annual award was conferred at the Chicago meeting of the American Society of Orthodontists on Dr. John V. Mershon, of Chicago, past-president of the society, who from 1916 to 1924 was head of the department of orthodontia at the University of Pennsylvania.

THE Comet Medal of the Astronomical Society of the Pacific has been awarded to Leslie C. Peltier, of Delphos, Ohio, for his independent discovery of Wilk's comet on February 27.

THE John Hunter Medal and Triennial Prize of the Royal College of Surgeons has been awarded to Laurence Frederick O'Shaughnessy, for his work on the surgery of the thorax.

DR. ATHERTON SEIDELL, of the National Institute of Health, U. S. Public Health Service, has been promoted by the French Government from the rank of chevalier to that of officer of the Legion of Honor.

DR. JAMES BRYANT CONANT, president of Harvard University, has been elected to honorary membership in the Chemists' Club, New York, N. Y.

DR. A. S. EVE, who retired two years ago as Macdonald professor of physics at McGill University, has been made president of the newly organized McGill Society of Great Britain.

DR. LOUIS F. FIESER, associate professor of chemistry at Harvard University, has been promoted to a professorship.

RECENT appointments of visiting professors at Yale University include: Dr. Robert H. Lowie, of the University of California, to serve as professor of anthropology for the first term of 1937–38; Dr. Charles G. Seligman, professor of anthropology at the London School of Economics, as Bishop Museum professor of anthropology for the second term, and Joseph W. Roe, of New York University, as professor of industrial management in the School of Engineering.

AT the University of Cincinnati, Dr. Charles N. Moore, professor of mathematics, will fill the newly established position of director of graduate studies in mathematics; Dr. Louis Brand, professor of mathematics and head of the department of mathematics in the College of Engineering and Commerce, will be chairman of the combined departments of engineering and of mathematics in the College of Liberal Arts; Dr. Walter H. Bucher, professor of historical geology, will become chairman of the department of geology and geography, and Dr. Arthur G. Bills, since 1927 assistant professor of psychology at the University of Chicago, has been appointed professor of psychology and head of the department of psychology in the College of Liberal Arts.

DR. JOHN N. SWAN, head of the department of chemistry at the University of Mississippi since 1915, having reached the age of seventy-five years, will retire at the close of the present academic year.

THE Chemical Foundation, Inc., of New York City, has appropriated $5,000 in support of the research work of Dr. Ernest O. Lawrence, professor of physics at the University of California.

DR. PHILIP FOX, director of the Adler Planetarium, has been elected director of the Museum of Science

and Industry, Chicago, to fill the position left vacant by the resignation of O. T. Kreusser, who recently joined the research staff of the General Motors Corporation.

Merrill Bernard, hydraulic engineer, has been appointed chief of the River and Flood Division of the U. S. Weather Bureau, to fill the vacancy caused by the death of M. W. Hayes. Mr. Bernard was with the U. S. Geological Survey from April, 1934, until June, 1935, on special hydrologic studies for the Mississippi Valley Committee, and with the Soil Conservation Service of the U. S. Department of Agriculture from December, 1935, until his transfer to the Weather Bureau.

Dr. Liberty Hyde Bailey, professor of agriculture emeritus at Cornell University and director of the Bailey Hortorium, has gone to Haiti, where he is making a collection of palms.

Dr. Herbert Francis Marco, of the U. S. Forest Service, is spending several months at the New York Botanical Garden doing laboratory research in connection with special studies in the breeding of forest trees, a work in which Dr. A. B. Stout is cooperating.

Dr. Elsdon Dew and J. de Bruijne, of the South African Institute of Medical Research, left Johannesburg on April 6 to investigate blood groups among native tribes in the two Rhodesias, Nyasaland, Tanganyika, Kenya, the Anglo-Egyptian Sudan, Uganda and the Belgian Congo. They are traveling in a motor-caravan and will be away six months.

The Edgar Fahs Smith Memorial Lecture will be given at the University of Pennsylvania by Dr. Charles H. Herty on Friday, May 21, at 8:15 P. M. He will speak on "Research the Guide for Sound Industrial Development."

Dr. Frederick Tilney, professor of neurology at Columbia University, will give the address at the annual initiation dinner of the Kappa Chapter of Sigma Xi at Columbia University on May 4. His subject will be "The Brain from Fish to Man."

Dr. George H. A. Clowes, director of research of the Lilly Laboratories, will give the eleventh annual series of Priestley lectures at the Pennsylvania State College from May 4 to 7. His subject will be "The Chemical and Physical Characteristics of Cell Structure and Function." The Priestley lectures, inaugurated in 1926 by members of the faculty of the School of Chemistry and Physics, constitute a memorial at Pennsylvania State College to Joseph Priestley. Since 1931 Phi Lambda Upsilon, honorary chemical fraternity, has cooperated in the presentation of the lecture series.

Dr. Leo Frobenius, founder and president of the Institute for the Morphology of Culture at Frankfort-on-the-Main, will give a lecture at the American Museum of Natural History on May 5 at 8:15 P. M. He will speak on "Prehistoric Art in Africa."

James A. G. Rehn, curator of entomology and secretary of the Academy of Natural Sciences of Philadelphia, addressed the Lancaster Branch of the American Association for the Advancement of Science on April 29. The lecture was entitled "Hunting Animals in Africa."

Dr. Madge Thurlow Macklin, of the University of Western Ontario, gave on April 15 the Catherine Milligan McLane Lecture at Goucher College, Baltimore. Her subject was "The Inheritance of Disease and its Relation to the Practice of Medicine."

The summer convention of the American Institute of Electrical Engineers will be held in Milwaukee from June 21 to 25.

The annual meeting of the American Pharmaceutical Association and its affiliated groups will be held in New York City during the week of August 16.

The twenty-fifth annual meeting of the Eugenics Research Association will be held at the American Museum of Natural History on June 5.

The annual meeting of the board of trustees of the National Park Association will be held on May 14 at the Cosmos Club, Washington, D. C.

The Museums Association of Great Britain will hold its annual meeting from July 5 to 9 at Newcastle-upon-Tyne.

The annual report of the Brooklyn Botanic Garden for 1936 records an attendance of nearly 1,600,000—an increase of 200 per cent. over 1926; an attendance of more than 54,000 in visiting classes from schools (increase in ten years, 44 per cent.), and an attendance of more than 67,700 at other classes and lectures—an increase of 146 per cent. Twenty-four pages are devoted to research in progress during the year. Of the year's budget, 51 per cent. was provided from private funds income and 49 per cent. from the tax budget appropriation of New York City. For a number of years the trustees of the garden have provided 50 per cent. or more of the operating budget.

At the twenty-fourth International Flower Show held in Grand Central Palace from March 15 to 20, the Brooklyn Botanic Garden installed an extensive exhibit of xerophytes, illustrating various ways in which plants meet the problem of drought. This exhibit included many plants from South Africa and various semi-arid regions. It was awarded the gold

medal and a special cash award, also an award of merit from the Garden Club of America. The Botanic Garden also exhibited four specimens, in flower, of the Devil's Tongue, *Amorphophallus* (*Hydrosme*) *Rivieri*. This exhibit, also, received a special award.

THE International Cancer Research Foundation has awarded to the School of Medicine of Temple University $6,000 to further the study started more than three years ago by Dr. Temple Fay, investigating the relationships between body segmental temperatures and the incidence of malignancy. Clinical observation has indicated that sub-normal temperatures and tissue refrigeration tend to inhibit abnormal cellular growth. The committee to administer this fund is composed of Dr. Temple Fay, professor and head of the departments of neurology and neurosurgery; Dr. Lawrence Weld Smith, professor of pathology, and Dr. William N. Parkinson, dean.

ANNOUNCEMENT of the gift of two telescopes which have been added to the equipment of the department of astronomy at Radcliffe College has been made by the trustees of the college. One is a photographic telescope made by Felker. The second is a Bausch and Lomb four-inch visual refractor. Both telescopes are mounted equatorially and have been erected in a small observatory on the roof of Byerly Hall, the science building where courses in elementary astronomy are conducted. Advanced students are privileged to use the facilities of the Harvard University Observatory.

THE Printing Industry Research Association has been founded in Great Britain for the purpose of supplying the trade with technical knowledge not only of type, paper and ink, but of the illustration processes most widely used—photo-engraving, lithography, photogravure. Bookbinding and box-making are also included. Printers vexed with problems arising from their work in any of these categories will be given specialist guidance on application to Patra House, the headquarters of the new association, which is maintained by the printing and allied trades in conjunction with the Government Department of Scientific and Industrial Research. The laboratories were opened by the Duke of Gloucester on March 9.

DISCUSSION

SEDIMENTATION IN A SMALL ARTIFICIAL LAKE

LAKES and reservoirs are often seriously affected by sediments which collect in them and which diminish their storage capacity. If erosion loss from the farms —sheet and gully wash—is not controlled, will sedimentation injure or destroy the work of the government in the great dams of the Muskingum Conservancy District and similar projects? If the water storage capacity of lakes and reservoirs is being seriously decreased by sedimentation, can this sedimentation be prevented or decreased? What factors are involved in the silting of reservoirs? These are some of the questions which may be raised in connection with observations of lake and reservoir silting. Obviously, the answer to these and other questions must be made from data collected from a number of different lakes and reservoirs. We, therefore, submit some observations taken in a small artificial lake in the hope that our observations, together with many other such observations, may prove of value.

On the campus of Muskingum College there is a small artificial lake, which has an area of about 40,750 square feet and a volume of about 410,000 cubic feet. In the fall of 1935 we made a study of the amount of silting which had taken place in the lake since its construction in 1915.

Before 1915 the site of the lake was occupied by two small streams which joined where the lake is now located. About 300 feet below the junction of these two streams an earth dam, 150 feet long and 75 feet wide at its base, was constructed across the valley. For a distance of 200 feet above the dam an area 150 feet wide was excavated for the purpose of forming a basin and in order to obtain earth for the dam. A vertical cement outlet which stands near the lateral center of the lake, 30 feet from the dam, has been provided to take care of the overflow.

As the lake was constructed it is an almost perfect settling basin; the only materials which escape are particles so fine that they do not settle out before the water goes over the outlet and material in solution.

A plane-table survey was made in order to obtain a map upon which the data were placed and from which the area of the lake was calculated. A silt rod was then used and the depth of the silt on the bed of the lake was determined as well as the depth of the water in the lake.

A mechanical analysis of the sediment was not undertaken, but note was made that where the two streams enter the lake the material was of visible shape, while farther from the streams the sediment was composed of fine material such as silt.

The coarser sediment was naturally deposited where the incoming streams dropped the heaviest portions of their load as their velocities were decreased upon entering the lake. While the total volume of this type of material is not as great as the volume of the finer materials the effect is more noticeable because of the concentration of the material near the mouths of the streams. At the mouth of one of the streams a delta

which contains about 17,236 cubic feet of sediments has been deposited since 1924. In 1934 a small island, composed of about 1,200 cubic feet of earth, was constructed as a nesting place for swans about 40 feet from the delta and directly in the path of the incoming stream. Since that date it has been connected to the delta by deposits of sediment, mostly shale and sandstone, the particles of which range from one half inch to two inches in diameter.

Beyond this coarse material a silt rod survey showed that the average thickness of the fine sediments which covered the bottom of the lake was 2.8 feet, while still farther from the incoming streams, near the dam, the average thickness was 2.4 feet. Computations of the total amount of sediment on the bed of the lake indicate that 102,800 cubic feet had been deposited between 1915 and 1935. In 20 years the water-holding capacity of the lake had been diminished 29 per cent. by silting. If we assume that the average weight of a cubic foot of silt is 100 pounds, this would mean that over 5,000 tons of silt have accumulated in this lake during the past 20 years.

There are several factors which have effected this deposition; the most influential one is probably the treatment of the farms and fields which drain into the lake. The water-shed is a small typical southeastern Ohio area of about 207 acres. This area was mapped in 1935 by the Soil Conservation Service as to soil erosion, slope and cover (cover meaning land use). Slightly less than half of the area is the property of Muskingum College and is used as college campus. This campus, from the standpoint of soil cover, may be considered as pasture, with the exception of a small area which is used as a baseball field and a small area of unpastured woodland. Approximately 12 acres of the water-shed are cultivated.

Most of the area is class 3 erosion.[1] In most of this particular area this would mean that from 4 to 7 inches of soil had gone down the streams and into the lake. There is one area of class 2 erosion, a small area in which we found from 6 to 8 inches of top-soil remaining. There are no serious gulleys in the area and only a few small places where the top-soil is entirely gone and the shaly sub-soil exposed. The soils of the area are all Muskingum soils, that is, residual soils of sandstone and shale origin, with the exception of a poorly drained flood plain of about one acre in area, which is Atkins silty clay loam.

In our analysis of the causes of deposition in the lake we found that construction work had probably been influential in affecting the sedimentation. Since the lake was constructed in 1915 a series of tennis courts, a baseball field and a football stadium have been constructed above the lake. All these have entailed extensive excavations and it is reasonable to believe that the process of sedimentation was greatly accelerated during these periods. However, we do not feel that the wash from these areas was the dominating influence in producing the sedimentation noted. The condition of the pasture fields, the campus and the cropped areas leads us to believe very strongly that sheet erosion and the small amount of gullying noted in the drainage area have had the greatest influence in producing the sediments which washed down the two small streams and settled in the lake.

R. H. Mitchell
G. Robert Hall
Muskingum College

[1] Class 3 erosion is used to indicate land from which 25 to 75 per cent. of the top-soil is removed.

A NEW COLOR TYPE IN CABBAGE

"Colored bud" is a brief descriptive name of a character found in an inbred line of cabbage in 1935 which to the writer's knowledge has not been previously described. Except for the light reddish purple color on the edge of the leaves of some plants, which may be the same as "sun color" previously described,[1] there is no external evidence that the terminal bud within the head is other than the usual white or pale cream in color. As the leaves are successively stripped away from the outside to the center, the leaf color is first green, then white (or cream) and finally pale pink or magenta.

The pinkish color is most intense on the edges of the small leaves surrounding the terminal bud and varies from 41B2 to 41C3 in terms of the "Dictionary of Color."[2] The color may be restricted to an area within one-half inch of the apex of the stem, or may extend over an area three inches in diameter surrounding the terminal bud. Upon exposure to light these colored leaves as well as the white ones soon develop a deep green color which obscures the other color.

The family in which this type first appeared comprised 84 colored and 32 white bud plants. Since the writer is unable to continue work with cabbage the remaining stock of seeds of this and related families is being sent to C. H. Myers, of Cornell University, for work on inheritance of colored bud and its relation to other color types. In correspondence dated November 2, 1936, Dr. Myers mentions the existence in his cultures of a type similar to the one described above.

This color type appeared in the third inbred generation from seed of a local variety of cabbage, purchased in the market place of Tashkent, Turkestan, U. S. S. R., by W. E. Whitehouse and introduced in the United States under number P.I. 82649 of the Division of Plant Exploration and Introduction of the

[1] Roy Magruder and C. H. Myers, *Jour. Agr. Res.*, 47: 233, 1933.

[2] A. Maerz and M. R. Paul, A Dictionary of Color, McGraw-Hill, New York, 1930.

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MAGNESIUM SULFATE—A NEW INSECTICIDE

DR. V. R. HABER discovered the insecticidal properties of magnesium sulfate (Epsom salts) several years ago. His tests showed that $MgSO_4$ used as a spray, in the proper concentration, constitutes an effective control for the Mexican bean beetle (*Epilachna corrupta* Muls.). This spray has many advantages over arsenical sprays, in that it is easily applied, easily removed in preparing beans for cooking, and is harmless to humans if ingested.[1]

Hawkins, in a paper on the wheat wireworm (*Agriotes mancus* Say), finds magnesium sulfate and magnesium chloride toxic to this form.[2]

The following work on grasshopper control by $MgSO_4$ is the outgrowth of Dr. Haber's suggestion. Since there were neither time nor facilities to make complete tests, the results are only preliminary.

Grasshoppers, confined in small insect cages, four per cage, were fed with bran baits made of bran, molasses and water, with $MgSO_4$ added for test groups. The control groups received the bait with no poison, while others received a 5 per cent. arsenic bran bait. The test groups received the standard bait with 5 per cent., 10 per cent., 15 per cent., 20 per cent., 25 per cent. and 30 per cent. $MgSO_4$ added.

From comparisons of the mortality rates among the different groups, the following formula for a grasshopper bait is proposed:

Bran	60 per cent. to 65 per cent.
Molasses	15 " "
$MgSO_4$	20 " " to 25 " "
Water	Enough to moisten.

This formula seems to be just as effective as the 5 per cent. arsenic bait, it is cheaper, and it is absolutely harmless to humans, cattle, swine and poultry or other birds.

These results indicate that $MgSO_4$ may be an insecticide of value for the control of mandibulate insects. As a spray, it could be used safely on many vegetables and fruits, with little danger to humans and domesticated animals eating such foods. It is cheap, easily dissolved and should be compatible with other insecticides. Entomologists with facilities for testing $MgSO_4$ as an insecticide against mandibulate insects should attempt to determine its value in the control of such forms.

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ANATOMICAL NOMENCLATURE

AT the annual meeting of the American Association of Anatomists, held at the University of Toronto on March 26, 1937, Professor C. M. Jackson, chairman of the Committee on Anatomical Nomenclature, made the following statement.

An account of the establishment of a permanent International Commission on Anatomical Nomenclature was published in the Anatomical Record, 1936, vol. 67, No. 1, pp. 1–6. This Commission adopted the NA system of nomenclature as the basis for revision, and requested that any desired changes be submitted before September, 1937. (The NA list was printed in the Anatomischer Anzeiger, Ergänzungsheft zum Band 81, 1936.)

Accordingly during the present year our American Committee has studied the question as to what changes should be proposed. Many difficult problems are involved. While the committee has not yet reached a final decision, it has agreed upon some questions of general policy. One is that in order to reconcile conflicting views it will be desirable for the present to use synonyms for some of the terms, as (for example) many of those of position and direction.

Any member of the Association may propose desired changes in the terms listed by the NA, and our committee would be glad to have these proposals for consideration. As the time is short, any such proposals should be submitted promptly, with reasons therefor. It is hoped that the final report of nomenclature with the recommended changes can be formulated in time to submit it to the Executive Committee of the Association for review and criticism before it goes to the International Commission.

GEORGE W. CORNER,
Secretary

SPECIAL ARTICLES

PHOSPHORESCENCE OF CELLS AND CELL PRODUCTS

A BODY which continues to give off light for a visually observable period of time after exposure to radiation is generally said to be *phosphorescent*.[1,2] Phosphorescence of inanimate systems has been studied rather extensively;[3] little attention, however, seems to have been paid to the phenomenon in cells and cell products. Thus while phosphorescence of tissues was

1 Personal letter from Dr. V. R. Haber.

2 J. H. Hawkins, Maine Agr. Exp. Sta., Bull. 381, 1936, p. 120.

1 R. A. Morton, "Radiation in Chemistry," 1928.

2 S. E. Sheppard, "Photo-chemistry," 1914.

3 P. Pringsheim, "Fluorescenz und Phosphorescenz," 1928.

noticed as early as the eighteenth century by Becchari, who found that "... if a person shut up in a dark room puts one of his hands out into the sun's light for a short time and then retracts it, he will be able to see the hand distinctly and not the other"[4] no further study seems to have been made until 1933. In that year Hoshijima[5] found that human bones, teeth, cartilage, nails and dried tendons as well as certain abnormal calcifications would phosphoresce following irradiation with a Hanovia quartz mercury lamp, while a number of tissues did not.

To determine whether the property of phosphorescence is wide-spread, various materials of biological origin were irradiated, at one centimeter distance from the edge of the tube, for ten-second intervals, with a mercury-argon discharge tube (emitting radiations, of which some 85 per cent. are of 2537A),[6] and the life of visible phosphorescence was observed with the 20–30 minute dark-adapted eye and recorded. Three to nine trials were made with each object and three subjects took part in the studies. In all cases the after-glow can readily be observed, even if the period of irradiation is reduced to one second or less, but it is more difficult to compare the life of visible phosphorescence in many of the materials; therefore the longer period was used throughout.

It was found that while frog cornea, lens, stomach, kidney, muscle, blood and skin of the back showed no observable phosphorescence, the skin of the belly of the frog and the skin of the back as well as the palm of the human hand emitted light for two to four seconds after irradiation. All the tissue products studied showed phosphorescence. Chitinous material (Limulus exoskeleton), silicious material (glass sponge) and cellulose materials (wood, leaves and flowers of several kinds) showed short-lived phosphorescence. Horny materials, such as human finger nails, bird bills and feathers (pelican) and a spongin sponge phosphoresced for as long as ten seconds or more. Calcareous materials, such as bones, shells (of mollusks) and teeth showed very long-lived phosphorescence (20 to 25 seconds), and strangely enough bean seeds phosphoresced for almost as long a time. In general, it may be concluded that tissues show little or no phosphorescence, but compact tissue products may be highly phosphorescent.

Live human teeth showed about the same life of phosphorescence as did dead teeth from the same individual; apparently the living constituents of the teeth have little to do with the after-glow in this case.

To determine which wave-lengths of light were effective in producing phosphorescence, several objects were irradiated with monochromatic light obtained by passing the radiations of a quartz mercury arc through a natural quartz monochromator. The intensity of the light was measured with a thermopile and galvanometer. The apparatus has been described in detail elsewhere.[7] The materials were irradiated and observed in the same manner as in the first set of experiments. It was found that very intense yellow light (5844A) excited no phosphorescence of teeth, bones and cotton, while blue (4350A) and violet (4050A) light of fair intensity induced just perceptible phosphorescence. All the ultra-violet wave-lengths tried excited phosphorescence, the shorter being most effective despite their low intensity; for while the intensities at λ's 3660, 3130, 3025, 2804, 2654 and 2537A were, respectively, 11.1, 8.5, 6.0, 1.0, 2.1 and 1.9 times the intensity at 2804A (12.54 ergs/sec./mm^2), the afterglow for the wave-lengths 3130 and shorter was 2 to 3 times that at 3660A for teeth and generally somewhat longer, when not markedly so, for cotton and bone. Thus the short ultra-violet is most effective, the long much less so and the visible region least effective in exciting phosphorescence in the objects tried.

There are two main groups of phosphorescent materials: (1) *organic materials,* such as dyes, of which Sheppard[8] says: "... all organic bodies possessing marked absorption bands in the ultra-violet seem capable of fluorescence in the dispersed medium or phosphorescence in a condensed condition, when excited by radiant energy of sufficient frequency"; (2) *inorganic salts,* such as the classic Lenard phosphors consisting of ZnS and CaS containing various metals as impurities. Some organic materials of biological origin such as starch and glucose, tested here, and gelatin, tested by Hoshijima,[9] even when chemically pure, show considerable phosphorescence. On the other hand, bone washed free of salts with HNO_3 is no longer phosphorescent.[10] In this case the inorganic salts are probably the phosphorescent agents. It is probable that both types of materials are responsible for biological phosphorescence, the constituent of greatest activity in any given case depending upon the composition of the material.

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[4] E. Darwin, "The Botanic Garden," p. 181, 1801.
[5] S. Hoshijima, *Sci. Pap. Inst. Phys. and Chem. Res. Tokyo* (*a*) 20: 109; (*b*) 21: 15 (1933).
[6] W. G. Leighton and P. A. Leighton, *Jour. Chem. Ed.,* 12: 139, 1935.
[7] A. C. Giese and P. A. Leighton, *Jour. Gen. Phys.,* 18: 557, 1935.
[8] S. E. Sheppard, "Photo-chemistry," p. 413, 1914.
[9] S. Hoshijima, *Sci. Pap. Inst. Phys. and Chem. Res. Tokyo,* 20: 109, 1933.
[10] *Ibid.*

THE CHEMORECEPTORS OF CERTAIN DIPTEROUS LARVAE

IN spite of the frequency with which the larvae of such dipterous insects as the blow-flies are used in experimental work, the correct assignment of function to certain of their sense organs is seldom made. The most conspicuous of these organs are two pairs which are located in papillae on the oral lobes. Each organ consists of a compact group of cells connected by a relatively large nerve to the larval brain and communicating with the exterior at the end of the papilla. The first mention of these which has been found in the literature was made by Newport,[1] who, in a description of the larva of *Oestrus ovis,* called them "organs of vision." From their position and structure Weismann[2] later ascribed to them the sense of touch, and recently, in a study of the structure and development of *Drosophila,* Strasburger[3] holds this same view. In his monograph on *Calliphora* Lowne[4] speaks of them as "eye-like organs," and it is to his description that reference is most often made. Hewitt[5] states that they are the only obvious sense organs found on the larva of the house-fly, *Musca domestica,* and concludes, "Judging from their structure the organs appear to be of an optical nature, and this is the usual view which is held with regard to their function."

With few exceptions, notably Patten[6] and Crozier and Kropp,[7] most investigators who have used blow-fly larvae in studies of their responses to light have accepted these earlier decisions, based entirely on anatomical studies, that the organs on the oral lobes are the photoreceptors. The work of Pouchet[8] has been almost completely overlooked, and unfortunately so, since he showed in a series of simple convincing experiments that these organs in question could not be the only light receptors, for, when they were destroyed by cautery, the larvae still reacted normally to stimulation by light.

The experiments performed by Pouchet have been repeated on *Lucilia sericata* with similar results. These organs are certainly not the photoreceptors of blow-fly larvae. Are they organs of touch or do they serve some other function? The results of the following experiment answer this question. Three pair filter flasks were connected by way of their side a and a piece of decaying meat placed in one member each of two pairs. Larvae were introduced into other member of a pair; the flasks were stoppered left in the dark for one hour. A count was then m of the larvae in each of the flasks. Table 1 give summary of the results of five separate tests:

TABLE 1

	Normal larvae		Larvae with oral papillae removed		Normal larvae
Flask	1	2	3	4	5
		(food)		(food)	
Distribution of larvae at beginning of tests	70	0	70	0	70
Distribution of larvae at the end of tests.	6	64	59	11	50

The great majority of the normal larvae passed fr Flask 1 to Flask 2, presumably being attracted th by the odor from the meat. Only eleven of the seve larvae with the receptors in question destroyed pas from Flask 3 to Flask 4, and this perhaps by chan for in the control with normal larvae and no meat the second flask twenty larvae wandered through connecting passageway and were found in Flask where there was nothing to attract them.

Thus it appears that at least one pair of the t pairs of sense organs on the oral lobes of *Lucilia se cata* is olfactory in function. There is some eviden from their structure that the two pairs do not ser the same purpose. The more dorsal ones have a ce tral cavity with a valve-like structure guarding opening of each to the exterior. The ventral orga are solid and the ends of the elongated sensory ce protrude through the opening in the papilla in such manner that they may come in direct contact with substrate. It is possible that the dorsal organs a olfactory and the ventral ones gustatory, althou there is no experimental proof that this is the case.

The photoreceptors of blow-fly larvae remain to identified. The cauterizing of various parts of oral lobes and segments of the so-called "head" d not affect in any marked way the response to lig It is possible that the photoreceptors are scatte throughout the head region and that it is difficult eliminate them all without serious injury to the lar Viallanes[9] described and figured a complex netwo of nerve cells lying under the hypodermis of diptero larvae, and in addition occasional groups of ce which he termed "peripheral ganglia." In cross s tions of the anterior end of *Lucilia sericata* t clusters of sensory cells have been found, located o on either side of the prothorax. Their position

1 G. Newport, "Insecta." Todd's "Cyclopedia of Anatomy and Physiology," London, 1836–39.

2 A. Weismann, *Zeitschr. f. wiss. Zool.*, 14: 187, 1864.

3 E. H. Strasburger, "Drosophila melanogaster Meig, Eine Einfuhrung in den Bau und die Entwicklung." Julius Springer, Berlin, 1935.

4 B. T. Lowne, "The Anatomy, Physiology, Morphology, and Development of the Blow-fly." Vol. I, R. H. Porter, London, 1890.

5 G. G. Hewitt, *Quart. Jour. Micro. Sci.*, 52: 495, 1908.

6 B. M. Patten, *Jour. Exp. Zool.*, 17: 213, 1914.

7 W. J. Crozier and B. Kropp, *Jour. Gen. Physiol.*, 18: 743, 1935.

8 G. Pouchet, *Rev. et Mag. de Zoöl.*, Sér. 2, 23: 129 and 225, 1871–72.

9 H. Viallanes, *Ann. Sci. Nat. Zoöl.*, Sér. 6, 14: 1, 18

... that they might well be concerned with light ...ption, but carefully executed experiments will be ...ssary in order to make this matter certain.

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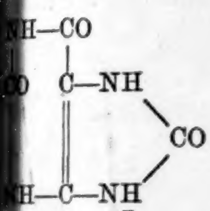
...E DISCOVERY AND IDENTIFICATION OF A NEW PURINE ALKALOID IN TEA

...LL the N-methyl derivatives of 2,6,8-trioxypurine I ...retically possible have been prepared synthetically, ...we have to-day a very complete knowledge of their ...istry. Emil Fischer and Heinrich Biltz, with the ...boration of many coworkers, are the two investi...rs who have contributed the most to our present ...wledge of the chemistry of these purines and their ...vatives.



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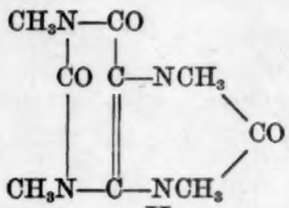

II

The occurrence of 2,6,8-trioxypurine as a product of purine catabolism in both the animal and plant kingdoms has been demonstrated conclusively, but, so far as the writer is aware, no N-methyl derivative of the purine I has, thus far, been shown to occur in nature. The author now presents this short note to report that the *tetramethyl-2,6,8-trioxypurine* represented by Formula II occurs in the mixture of purine alkaloids extracted from tea. It has been separated in a pure condition from such extracts, and has been shown to be identical with *1,3,7,9-tetramethyl-2,6,8-trioxypurine II* (tetramethyluric acid), which was first described by Emil Fischer[1] in 1884. Just as soon as proper and sufficient experimental material becomes available for the continuation of our plant extract researches, it is the intention of the author to search for this alkaloid and other N-methylated purines in the purine extracts of coffee and other plants. The results of this research program will be discussed in future papers to be presented for publication in the *Journal* of the American Chemical Society.

TREAT B. JOHNSON

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...CIENTIFIC APPARATUS AND LABORATORY METHODS

... CONDENSER DISCHARGE STIMULATOR FOR PHYSIOLOGICAL PURPOSES

...HE stimulator described in this report has been ...gned for the determination of the adequate shape ... duration of current pulses used as stimuli on the ...bral motor cortex.[1] It has been found a useful ...ice for general stimulation experiments wherever ...attempt is made to gain more information about ...excitable structures responsible for a certain effect. ...lso provides for a selective stimulation[2] in mixed ...ipheral nerves or in mixed tracts or centers within ...central nervous system.

...he set-up is based on the principle of condenser ...charges adapted to the relatively low resistance of ... tissue to be stimulated through a single-stage ...er amplifier.[3] It allows stimulation with alternat... single or double condenser discharges whose dura..., *i.e.*, time constant, can be changed over a wide ... range (from .01 to 100 or 1000 milliseconds) ...hout any change at all in the amplitude (peak in...sity) of the discharges. The stimulating voltage, ...to 10 or 20 volts, is led off from a potentiometer ...2,000 ohms maximum resistance. Any influence ...he stimulating circuit upon the time constant of the ...denser system is excluded.

From a source of potential A two condensers C and C^1 of different capacities are charged by make of K over two identical resistances R and R^1 to the same voltage, and they discharge over the same two resistances and a common resistance S, low in comparison with R and R^1, when K is opened. The resulting potential wave between x and y has its shape and direction determined by the ratio of one capacity to the other. It represents an ordinary condenser discharge if one condenser is disconnected, and a double condenser discharge (see[3]) if both condensers are placed in the circuit. Any such potential wave between x and y causes in the plate circuit of the amplifier tube AT (Cunningham 2A3) a current wave of identical shape. The resting plate current of AT is compensated by another similar tube CT with adjustable heater resistance. Equilibrium between the two tubes, *i.e.*, absence of potential between the ends of the potentiometer p, is controlled by a high resistance galvanometer v. Both halves of the potentiometer are divided into twenty intervals of 50 ohms each. Provided that the stimulating current is always led off from two symmetrical steps on the corresponding halves of the potentiometer, the current in the stimulating circuit is only due to, and directly pro-

...1 O. A. M. Wyss and S. Obrador, *Am. Jour. Physiol.*, ...ress (1937).

...2 O. A. M. Wyss, *Schweiz. Arch. f. Neur. u. Psych.*, 28: ..., 1932.

1 Emil Fischer, *Ber.* 17: 1784 (1884); also *Ber.* 30: 3009 (1897).

3 *Idem.*, *Pflüger's Arch.*, 233: 754, 1934.

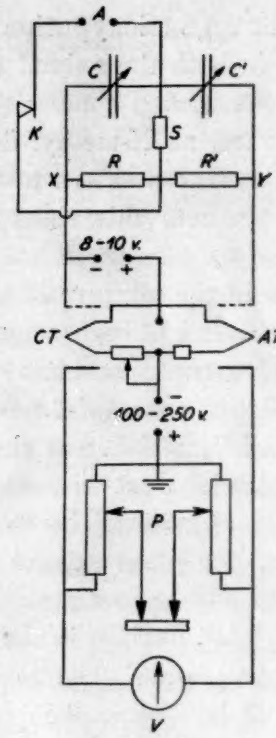

FIG. 1

portional to, changes in the plate current of AT; its shape, therefore, is that of the potential wave between x and y.

For double condenser discharges the most convenient ratio between C and C^1 has been found to be 2 to 1 (see[3]). The resulting peak potential between x and y reaches then 25 per cent. of the applied voltage A, whereas for single condenser discharges the full potential appears between these two points. Therefore, from a dry cell battery used in A, 36 volts were picked out for double condenser discharges and 9 volts for single condenser discharges. The condensers C and C^1 are variable from .001 to 1, or very slow current waves, 10 microfarads.[4] With two pairs of identical resistances for R and R^1, of 10,000 ohms and 100,000 ohms, respectively, a range of time constants as wide as 1 to 10^5 can be covered. The resistance S has to be kept as low as possible; a few hundred ohms are negligible, even with 10,000 ohms in R and R^1.

The duration of the single current pulse is determined (a) for single condenser discharges by the time constant: resistance $R \times$ capacity C, and (b) for double condenser discharges by the duration of the rising phase which is equal to $0.7 \times R \times C$, C being the greater capacity ($C = 2\ C^1$). The time values are obtained in seconds if R and C are expressed in ohms and farads, respectively. If, therefore, for R and R^1 two pairs of resistances of either 14,500 or 145,000 ohms are used, the duration of the rising phase of the double condenser discharge is directly given by the number of microfarads of the greater capacity, one microfarad corresponding to 10 or 100 milliseconds, respectively. The full wave duration is approximately five times the rising phase, which has to be considered if repetitive stimulation is used. In the latter case the ordinary contact key K has to be replaced by an automatic commutator.

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[4] Decade condensers of General Ralio Company, Cambridge, Mass.

A METHOD FOR OBSERVING THE LOWER SURFACE OF SMALL OBJECTS

WHERE a simple device for examining the lower surface of small objects under the dissecting microscope is needed, a mirror may be used as a supplementary stage. The upper surface of the object can then be viewed by reflected light in the usual way, or by racking the microscope down twice the thickness of the mirror, the image of the lower surface of the object may be brought into focus. The object itself rarely causes any trouble while viewing the image; as, if the mirror is of adequate thickness, the object will be out of the line of vision and out of focus, often being entirely invisible. For the lower magnifications, where the objectives have a great depth of focus, the thickness of the mirror may need to be increased either by adding a supplementary glass plate or by raising the slide above the mirror on plasticene legs. This device, which no doubt has been repeatedly used, has several advantages, namely, the cheapness and availability of the material; the excellence of the illumination; and the speed and ease of changing views without the necessity of touching the slide or removing the hand from the focusing adjustment.

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